insure the proper amount of clay being added to the gravel. This will vary according to the size and character of the aggregate and the plasticity of the clay. The Michigan State Highway Department has a design chart for stabilization of loose material that can be used to great advantage. The clay needed can roughly be estimated to be approximately 10 per cent of the loose material on the road. New gravel placed on the road should not be larger than ¾ to 1 inch in size; and if the old road has larger loose stones, they should be removed.

It will be noted that holes develop at farm drives and at road intersections. This seems to be due to traffic slowing up at these locations and making quick starts, causing the wheels to tear into the road. If the stabilization is extended to cover these places, this can be avoided.

We intend to start our work earlier for the coming year and do as much work as possible during the season of most rain in order to avoid the dry summer when the dust becomes intolerable. Last year there were very few days that the work could not have been carried on, and several miles were finished before the summer was advanced.

By selection of proper materials and their correct application we are getting a stabilized road surface that is standing up under ordinary traffic conditions and is answering the needs of the landowners by providing a hard, dustless road. It is our intention to blacktop several miles of road that has been so treated, and we plan to extend this stabilization to the secondary roads leading into the main traffic lanes. The highway officials of our county are convinced that there should be some sort of improvement to serve those who do not live on our main highways and that our limited income can be spread over more miles in this way than in any other. In other words, we are working out a planned program to give us the types of roads best suited to our traffic demands, placing them *where* they are most needed *when* they can be afforded.

It is relatively simple to build high-type roads expensively, but to build them at a cost which is within our budget is another matter. We feel that we have solved the problem by keeping our low-cost roads really low in cost and our high-type roads as high in type and low in cost as possible and yet building them according to good engineering principles.

ROADSIDE MOWING—METHODS AND COSTS

Ray Linn,

Montgomery County Road Supervisor

Roadside mowing is a rather new maintenance operation in most Indiana counties. For many years the law provided that farmers must mow the roadsides along their farms and were entitled to a road tax credit of $3.00 for each day spent in mowing. This law remained on the statute books long after all

direct forms of road taxes were abolished, and caused considerable misunderstanding and irritation. Finally, within the past few years, the legislature passed a law requiring the various highway departments to "cut down and remove" all tree sprouts, willows, thistles, burrs, and so on growing along the county highways between June 15 and September 1 of each year.

In Montgomery County this additional work came as a serious blow to an already overburdened budget; and yet we, in common with most county road officials, had long realized the danger hazards resulting from high weed-growths at intersections and around bridge wings and narrow culverts.

Most of our 848 miles of county highways are in level or comparatively level country; but twenty to thirty per cent, particularly those around The Shades and Turkey Run areas along Sugar Creek in the southwest part of the county, are as rough and hilly as any highways in the state.

We quickly found that mowing is a very tedious and disagreeable maintenance job, unpopular with the employees and expensive. But no other maintenance operation will so improve road appearance or benefit the ordinary highway user as much for the money spent as right-of-way mowing.

We have discovered, too, that the job divides itself into two programs: what might be called the long-range program and the annual program. Outside ditches along roads in limited rights-of-way are often narrow and deep trenches across which ordinary mowing machinery cannot operate. Because the rights-of-way had been more or less disregarded for several years, there were accumulations of old wire fence, bottles, cans, stones, small trees and willows, and other obstructions which made any kind of mowing slow, difficult, and costly.

Accordingly, in our long-range program for the past three years we have had men at work cutting brush, removing obstructions, and so on. We have used our tractors in pulling small trees and hedges, useless posts, and other similar obstacles. With this sort of work once done on a particular stretch of highway, the annual mowing by machine will usually prevent its having to be done again.

Another phase of our long-range program has been the improvement of side-ditches to facilitate machine mowing. Many years would be required to bring them all up to the best standards, and most of our roads would have to be surveyed and widened before proper ditches could be built; but on all new black-top work we try to build new side ditches that are accessible to the highway mowers. Our usual method calls for a 50-foot right-of-way in level country, with as much additional as is needed at fills and cuts. On this right-of-way we make the ditches as shallow as feasible, with gently sloping back slopes, so that mowing in the future can be more quickly and efficiently done. Incidentally, this type of ditch is much less apt to be clogged or stopped entirely by the weeds and grass

left on the ground by the mower. Of course, it will take years to bring all our highways up to this standard; but we proceed on the principle that "every little helps."

Another problem that every county will have to settle is whether to cut one swath on each side of the roadway three or four times a season—or to mow the entire right-of-way perhaps once a year and thus leave it in weedy condition a good part of each season. Our country road systems contain thousands of miles where it is practically impossible to mow more than one swath on each side; but that is a great help and will expose most ditches, blind culverts, bridge wings, and similar obstructions. Consequently, where fence-to-fence mowing is impracticable, we emphasize keeping one swath on each side clean, and perhaps do hand mowing around obstacles.

It is particularly important to have side-ditches well mowed at least two or three times each season. If the side ditch is kept mowed, run-off water will be carried away quickly. But if weeds are allowed to grow large before cutting and are then permitted to lie in the side ditches, they will be accumulated by floods at small culverts and catch basins and sometimes will shut off the flow of water in the ditch proper. The resulting drainage blocks will cause wash-outs and other expensive damage.

EQUIPMENT

The question of equipment for roadside mowing is one upon which there is much variation of opinion. The question usually is one of privately-owned horse-drawn equipment as opposed to tractor-drawn, county-owned machines.

We did our first season's mowing by hiring farmers, who used horse-drawn mowers. We paid them more than $4,000 for their work, but the results obtained were far from satisfactory. This casts no reflection on the farmer-operators, but rather shows that the ordinary farm mowing machine simply is not suitable for highway work. For one thing, the horse-drawn machine moves too slowly when back-tracking or by-passing a farm where the occupant takes pride in keeping up his own side-ditches and fence-rows. Again, there are definite and sometimes short strips where weeds grow much more rapidly than in other areas; and it is sometimes necessary for a mower to travel long distances where mowing is unnecessary merely to reach a short strip where it is needed. Finally, ordinary farm equipment will not handle—even when power-propelled—the large weeds and small tree shoots that special highway equipment can cut. There is, of course, a limit to the size that highway mowers will handle, but they are heavier in construction and much less subject to breakdown than farm machines.

Our commissioners, therefore, chose power mowers over the horse-drawn type; and from subsequent experience, they have

chosen special highway mowers as superior to tractor-powered farm mowers. Our mowing equipment now consists of five small gasoline-propelled tractors with special heavy-duty highway mowers attached, using only heavy-duty guards and cutting bars. Our tractors are of the four-wheel type and are equipped with starter and lights so that mowing can be done up to the last possible moment before darkness. They have speeds of 20 m.p.h. and up, which make it possible to get them to and from a specific mowing area quickly.

Tire chains, bottles, old wire, pasteboard boxes, old guy wires and cables are only a few of the hazards that a mower operator finds many times a day hidden in weed patches to menace his equipment. In beginning our program, our operators lost a lot of time in going to the garage for replacement of damaged sickle bars or guards; but now each machine carries three extra sickle bars, a box of sections, a few guards and guard bolts, punches, a hammer, a small anvil, and other tools necessary to make simple roadside repairs.

Our early equipment had manual control for adjusting the different positions of the cutting bar while in operation. The three newer machines have a power adjustment. We find the latter to be far more satisfactory, since it permits mowing directly up to mail-box posts, bridge heads, telephone poles, etc. Moreover, being able to raise the cutter-bar to a vertical position eliminates a lot of hand work in mowing back slopes of cuts, ditches, and fills.

Section knives used on our mowers are serrated on the bottom side. This type of knife is as easily ground as any plain smooth section, but we find it superior to the plain section.

Operating Methods

We have found that when mowing is extremely heavy and tough, it is easier to mow one swath only, and then, after the cut weeds have wilted and dried, to follow with a second or third cut as needed. The time allowed for drying, of course, depends entirely on weather conditions.

During the 1941 season we were able to mow our entire 848 miles of county highways twice on gravel roads, three times on all black-top roads, and four times on a few very important roads. The best results seem to be obtained by doing the most mowing on the most heavily travelled roads, with exceptions made in favor of particularly dangerous or other exceptional spots.

Operating methods must be varied somewhat to suit different operators, because there is a great difference in efficiency of men. The amount of mileage a particular man can cover in any one day varies widely with roadside and weather conditions. Hence, daily and man-hour averages have very little significance for Montgomery County and none at all for other counties with different conditions. On a few of our roads, a 40-mile-

per-day average can be maintained by a capable operator; but other roads and other operators might average only ten or twelve miles daily. As highways are mowed year after year, the average speed should improve materially, both because of improved roadside terrain and because operators will become more thoroughly acquainted with equipment and specific conditions.

Operating costs quoted here are based upon the entire 1941 season, consisting of 1,155 hours of mowing time. During this time, the mowers travelled 4,230 miles, using 634 gallons of fuel, or an average of 5½ gallons per day per machine. Mower repairs for the season were $99.51 for materials only, labor being by the county garage staff. Oil consumption was only $1.08. The entire cost of mowing the county highways during the 1941 season of 115½ days, including salaries and all expenses, but not including depreciation of machinery, was $649.33, or an average of 15.3 cents per mile of roadside mowed.

The mileage in these figures represents the distance travelled by one mower in mowing one five-foot cut only, and not the entire mileage involving one to three cuts on each side of the road. Necessarily, the cost figures include mowing under all sorts of conditions during the season beginning about June 15 and extending to late October.

OPERATING A COUNTY-OWNED GRAVEL SCREENING AND CRUSHING PLANT

E. F. Lamb,

Howard County Road Supervisor

Howard County has owned and operated a gravel screening and crushing plant for thirteen years. Our main roads have been graveled with crushed material from this machine with very good results. In preparing the material for a base on which a bituminous surface is to be placed, this crusher is supplied with a revolving screen with a one-inch opening, so that the material has to be smaller than one-inch in size to pass through the screen. The crusher has a capacity of from 175 to 200 cubic yards daily, depending, of course, on the size of the rocks to be crushed.

This is a jaw-type crusher that can be adjusted for either fine or coarse crush. We have found that if we crush our gravel much finer than ¾-inch in size, sharp pebbles will result, which cause damage to truck and automobile tires. We have noted damage to our equipment from this source; and rather than make the gravel any finer, we run the sand and gravel through the one-inch screen. This produces a very good road maintenance material and also makes maintenance much easier and more economical with our equipment, consisting of four maintainers drawn by tractors.